Lanthanum chloride or lanthanum carboxylate for orthophosphate removal in seawater aquarium - a feasibility study

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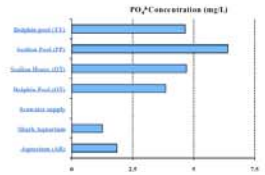
Abstract

This study is to evaluate the efficiency of orthophosphate (PO_4^{3-}) removal from marine aquarium with La(Cl)$_3$, the "Starver" by LoChlor and the laboratory prepared La(gly)$_3$ and their impact on turbidity and pH. Both results at the laboratory and in situ verification indicated the efficiency of PO_4^{3-} removal depends on filtration efficiency. Lanthanum compound could pass through sand filters into pool, according to the turbidity increment after treatment. Application of lanthanum compound to an aquarium has to be managed very carefully

Introduction

- High concentration of orthophosphates (PO43-) in dolphin pool and aquariums favors rapid growth of benthic algae at Ocean Park Hong Kong.
- A team of divers are subsequently required to conduct regularly cleaning



- To reduce PO_4^{3-} concentration, some aquarium have applied lanthanum chloride (La(Cl)$_3$ and found careful management of the dosing rate can reduce PO_4^{3-} level to 0.05ppm without leaking residual lanthanum.
- However, some aquarist encounted fish mortality (Ennevor, 1994) and others (Mills, 2005) found very fine La(Cl)$_3$ particles could be carried through sand filters into the pool water and cause cloudiness in the pool. Lanthanum phosphate particles in the pool would continue to provide a source of phosphate for algal growth.
- Both Mills (2005) and Starver by LoChlor claimed lanthanum glycolate (La(gly)$_3$) could remove PO_4^{3-} without causing high turbidity problem and have no impact on pH, thus suitable for any type of aquatic animal exhibit.

Objectives

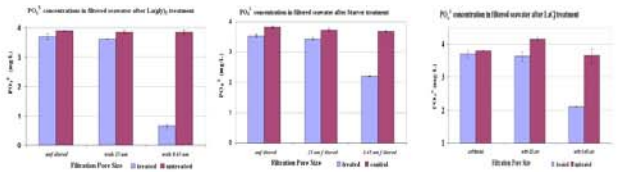
- To identify the feasibility of applying Starver product, La(gly)$_3$ or the La(Cl)$_3$, to our aquarium for PO_4^{3-} removal,
- To evaluated their impact on pH and turbidity,
- To verify the results of laboratory experiments with La(gly)$_3$ at a marine mammal system.

Laboratory Experiments

Method

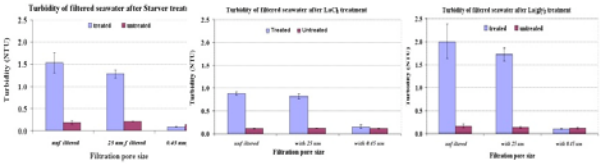
- For each trial, each of the six 15L bottles (3 for treatment and 3 as control) was filled with 10L of seawater of a marine mammal pool, respectively.
- Witih 4.84mg/L LaCl$_3$ trial: 2 ml of 24.2mg/ml LaCl$_3$ concentration were dosed to 10L seawater.
- With 5.4mg/L La(gly)$_3$ trial: 0.1ml of prepared 538mg/ml La(gly)3 was added to 10 L.
- With 5.32mg/L La(gly)$_3$ of "Starver" trila: 0.4mL of Starver (133g/L La(gly)$_3$) was added to 10 L.
- Both treated and untreated seawater were aerated for 24 hours at room temperature. Turbidity, pH and concentration of PO_4^{3-} in each bottle were measured before and after filtration through a 25um filter or a 0.45um GF filter.

Results and discussion: Efficiency of PO_4^{3-} removal



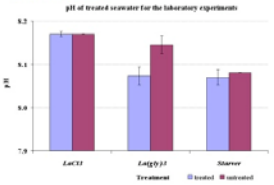
- Without filtration, PO_4^{3-} in all treated seawater were similar to control.
- Filteration through 25 µm filter removed 2-3% of PO_4^{3-} only in all treatments.
- Filteration through 0.45 µm removed 80% of PO_4^{3-} in La(gly)$_3$ treated but only 42% in La(Cl)$_3$ and Starver treated seawater.
- Thus, the efficiency of PO_4^{3-} removal depends the pore size, the smaller the pore size, the higher the efficiency.
- La(gly)$_3$ likely formed larger lanthanum PO_4^{3-} compound than La(Cl)$_3$ and Starver

Impact on turbidity

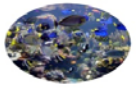


- Without filtration, all treated seawater increased turbidity.
- Filtration with 0.45µm reduced more than 82% turbidity but no reduction with 25 µm filter. The chemicals formed < 25 µm but > 0.45 µm lanthanum compound particles.
- Turbidity removal with 0.45µm was more efficient in La(gly)$_3$ and Starver than La(Cl)$_3$ treated water.
- Therefore, it is necessary to have efficient filtration system for any facility intended to apply either La(Cl)$_3$ orLa(gly)$_3$.

Impact on pH



- Although La(gly)$_3$ is more efficient in phosphate removal, it slightly decreased pH compared without significant with either La(Cl)$_3$ or Starver.



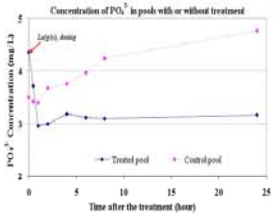
Verification with La(gly)$_3$ at a marine mammal facility

Method

- Two marine mammal pools of 51 m^3 each were used for this trial, one as the control and the other is for treatment. Each pool has independent life support system.
- 280 g of La(gly)$_3$ was poured into the strainers before 3 sand filters evenly. Parallel water samples were collected from both treated and control at time of 0, 0.5, 1, 2, 4, 6, 8 and 24 hours after treatment. Those samples were measured for pH, turbidity and PO_4^{3-} concentrations.

Results and discussion: Efficiency of PO_4^{3-} removal

- After adding 5.4 mg/L La(gly)$_3$ and completed first circulation (0.5hr), PO_4^{3-} in the pool decreased to 3.7 mg/L from 4.3 mg/L. After the second circulation, PO_4^{3-} further decreased to 3 mg/L. However, PO_4^{3-} removal rate slowed down, may be due to the dose was exhausted.
- In the control pool, PO_4^{3-} remained 3.5 mg/L after first circulation (1.5 hrs) and gradually increased to 7.9 mg/L due to accumulation of biological waste. No further increment was observed in the treated pool.
- Both laboratory experiments and in situ verification disclosed the 1ppm PO_4^{3-} was removed by 5.4 ppm La(gly)$_3$ (or ratio of 1:5). The lower than 1:1 might be due to more ions in seawater than in freshwater, as lanthanum can bond and flocculate other minerals (Tokunaga; 1999).



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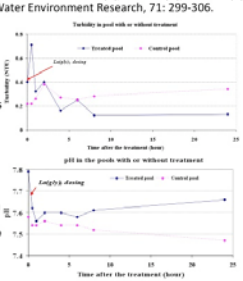
Impact on turbidity and pH



- Turbidity increased from 0.4 to 0.7 NTU immediately (<30 mins) after the dosing. No all La(gly)$_3$ could be loaded onto filters immediately as flocculent to capture PO_4^{3-} through mechanical filtration, some of the aqueous La(gly)$_3$ passed through the filters after dosing.
- Amount of La(gly)$_3$ loaded to the filters gradually increased through circulations so that the turbidity gradually decreased from 0.4 to < 0.15 NTU and maintained over the 24hrs, as compared to the stable turbidity in the control pool.
- Similar to the results of laboratory experiments, addition of La(gly)$_3$ decreased pH from 7.8 to 7.6 immediately. The gradual pH decrease in control pool was likely due to the accumulation of biowaste from the sealion after suspension of filter backwash and water renewal.

Conclusion

- *Although all lanthanum compound tested can remove PO_4^{3-} from seawater, the efficiency of removal depends on the pore size of filters. Lanthanum compound could pass through filters and increase turbidity inside pool.*
- *Lanthanum particles can cause significant mortality to Daphnia due to clogging filtration (Barry and Meehan, 2000). Lanthanum particles passed into pool could also potentially be trapped by gill lamellae of fish.*
- *Therefore, application of lanthanum compound to an aquarium has to be managed very carefully and better to be conducted in a side loop equipped with high efficient filters to avoid any potential adverse impact on aquatic organisms due to leakage of lanthanum compound to the pool.*